SPECIFICATION

TITLE OF THE INVENTION

5

PRINTING APPARATUS AND PRINT CONTROL METHOD

CLAIM OF PRIORITY

This application claims priority under 35 U.S.C.

10   § 119 from Japanese Patent Application No. 2002-222022

filed on July 30, 2002, entitled "Printing Apparatus

and Print Control Method", which is incorporated herein

by reference.

15   FIELD OF THE INVENTION

The present invention relates to a printing

apparatus and a print control method, and more

particularly, to a printing apparatus and a print

control method for performing printing using an ink-jet

20   printhead.

BACKGROUND OF THE INVENTION

Generally, an ink-jet printing apparatus has a

25   carriage holding a printhead and an ink tank,

conveyance means for conveying a print medium such as a

print sheet, and control means for controlling these

elements. In the ink-jet printing apparatus, printing is performed by scanning an ink-jet printhead (hereinbelow referred to as a "printhead"), having plural ink discharge orifices (hereinbelow referred to as "nozzles") to discharge ink droplets, in a direction (main scanning direction) vertical to a print medium conveyance direction (subscanning direction) while ink is discharged to the print medium. At this time, as a large number of nozzles to discharge ink are arrayed on a straight line in the subscanning direction, printing is performed for a width corresponding to the number of nozzles by scanning of the printhead on the print medium once. Accordingly, the printing speed can be easily increased by increasing the number of nozzles and increasing the printing width of the printhead.

Further, in a printhead where plural printing elements are arrayed in a line, these plural printing elements are divided into plural groups, and the plural groups are time-divisionally driven, sequentially, thereby a printing operation is performed. The number of concurrently-driven printing elements and the number of nozzles to perform concurrent ink discharge are determined in accordance with the number of groups of printing elements.

In the ink-jet printing apparatus, it is assumed under the condition that an environmental temperature and the temperature of the printhead are constant that

2

the same printing density can be obtained by applying the same amount of energy to the printing elements. However, in a case where plural printing elements are divided into plural groups and the groups are time-divisionally driven as described above, the number of concurrently-driven printing elements within one group changes in accordance with an image signal inputted into the printhead. If the number of concurrently-driven printing elements is increased, the amount of an electric current which flows through a common conductor to supply drive power to the plural printing elements is increased.

As a result, a drive voltage applied to the respective printing elements drops, and the energy applied to the printhead is changed, thus a variation occurs in the printing density.

Assuming that a resistance value of the common conductor is R, and a current which flows through one printing element is I, the voltage drop (V_{drop}) is expressed as

$$V_{drop} = R * I$$

Accordingly, in a case where n printing elements are concurrently driven, the voltage drop (V_{drop_n}) is expressed as

$$V_{drop\_n} = R * nI.$$

3

When all the printing elements belonging to a time-divisionally driven group are driven, i.e., when the number of concurrently-driven printing elements is a maximum (when the drive voltage drop is maximum), in order to realize stable ink discharge, the energy applied to the printhead is determined in consideration of the maximum number of concurrently-driven printing elements. However, in the case where the energy applied to the printhead is determined in this manner, if only one printing element is driven, excessive energy is applied to the printing element, and which harmfully affects the durability of the printing element.

Conventionally, as a countermeasure to this drawback, Japanese Published Unexamined Patent Application No. Hei 9-11504 discloses measuring the number of concurrently-driven printing elements in one group and determining a parameter for a drive pulse to be applied to the printing elements in correspondence with the measured number. In this manner, the energy applied to the printhead is changed in correspondence with the number of concurrently-driven printing elements, thereby maintaining the durability of the printing elements and stabilizing the printing density.

In recent years, there is an increasing need for higher image quality, and in response to the need, the size of discharged ink droplets are reduced in various

4

methods in the ink-jet apparatus. For example, if printing is performed on a print sheet using small size of ink droplets, a high-quality image without graininess can be obtained in a low printing duty area,

5   while in a high printing duty area, as an image with sufficient density cannot be formed by one ink discharge, the image must be formed by plural times of ink discharge. As a result, the printing speed is lowered.

10   Accordingly, to achieve high-speed printing and high-quality printing, a printing apparatus which forms an image using ink droplets in plural sizes is proposed.

Assuming that a heater resistor of a printing element to discharge a large size of ink droplet is r1,

15   that of a printing element to discharge a small size of ink droplet, r2, a drive voltage, VH, and a resistance value of a common conductor to supply drive power, R, an electric current I1 which flows through the heater resistor r1 and an electric current I2 which flows

20   through the heater resistor r2 are expressed as

$$I1 = VH/r1, \text{ and } I2 = VH/r2,$$

and the respective voltage drops (V_{drop1} and V_{drop2}) are expressed as

25        $$V_{drop1} = I1 * R, \text{ and } V_{drop2} = I2 * R$$

That is, the voltage drop values are different.

5

Fig. 12 is a graph showing the relation between the number of concurrently-driven printing elements and the voltage drop.

In Fig. 12, 1200a denotes a voltage drop by the heater resistor r1, and 1200b, a voltage drop by the heater resistor r2. The difference between these voltage drops increases in correspondence with the number of concurrently-driven printing elements.

In this manner, in a printing apparatus which forms an image using ink droplets in plural ink sizes, the voltage drop values, which occur in the printing elements used for discharging the respective size ink droplets, are different. Accordingly, it is desirable to set an optimum drive parameter to define the drive pulse to be applied to the printing elements in correspondence with the number of concurrently-driven printing elements.

SUMMARY OF THE INVENTION

Accordingly, the present invention is conceived as a response to the above-described disadvantages of the conventional art.

For example, a printing apparatus and a print control method according to the present invention is capable of forming an image using ink droplets in plural sizes, which obtain excellent discharge without

6

reducing the life of printhead.

According to one aspect of the present invention, the foregoing object is attained by providing a printing apparatus for performing printing by

5   discharging ink from an ink-jet printhead, having plural printing elements capable of discharging ink droplets in plural sizes, to a print medium, comprising: input means for inputting print data; count means for counting the number of concurrently-driven

10 printing elements corresponding to the respective one of the plural sizes, based on the print data inputted by the input means; determination means for determining a drive pulse applied to the concurrently-driven printing elements corresponding to the respective one

15 of the plural sizes, based on the result of counting by the count means; and print means for performing printing by applying the drive pulse determined by the determination means to the concurrently-driven printing elements.

20   It may be preferable that in the printing means, the plural printing elements are divided into plural blocks, and the plural printing elements are time-divisionally driven in block units using a double pulse, and that the count means counts the number of printing

25 elements concurrently-driven in block units.

Accordingly, to actually perform the above counting, it may be preferable that the count means

further includes: a first counter that counts the
number of concurrently-driven printing elements, among
a first group of printing elements corresponding to
discharge of first size of ink droplets, in block

5   units; and a second counter that counts the number of
concurrently-driven printing elements, among a second
group of printing elements corresponding to discharge
of second size of ink droplets.

Further, it is preferable that the determination

10   means determines a waveform of a double pulse applied
to the first group of printing elements and the second
group of printing elements, based on the result of
counting by the first counter and the result of
counting by the second counter, by, e.g., determining a

15   main pulse width.

Note that upon the above determination, it is
preferable that the determination means further
includes storage means for storing plural main pulse
widths, and the determination means performs a

20   weighting operation on the result of counting by the
first counter and the result of counting by the second
counter, and accesses the storage means based on the
result of the weighting operation to determine a main
pulse width to be applied to the first group of

25   printing elements, while the determination means
performs another weighting operation on the result of
counting by the first counter and the result of

8

counting by the second counter, and accesses the storage means based on the result of another weighting operation to determine a main pulse width to be applied to the second group of printing elements.

5   Further, it may be preferable that the ink-jet printhead has a nozzle array in which a first type of nozzle to discharge a first size of ink droplets and a second type of nozzle to discharge a second size of ink droplets are alternately arrayed. In this case, the

10   first type of nozzle has a first type of electrothermal transducer to generate thermal energy to be supplied to ink for discharging the first size of ink droplets utilizing the thermal energy, and the second type of nozzle has a second type of electrothermal transducer

15   to generate thermal energy to be supplied to ink for discharging the second size of ink droplets utilizing the thermal energy.

       According to another aspect of the present invention, the foregoing object is attained by

20   providing a print control method for performing printing by discharging ink from an ink-jet printhead, having plural printing elements capable of discharging ink droplets in plural sizes, to a print medium, comprising: an input step of inputting print data; a

25   count step of counting the number of concurrently-driven printing elements corresponding to the respective one of the plural sizes, based on the print

9

data inputted at the input step; a determination step of determining a drive pulse applied to the concurrently-driven printing elements corresponding to the respective one of the plural sizes, based on the

5   result of counting at the count step; and a control step of performing printing by applying the drive pulse determined at the determination step to the concurrently-driven printing elements.

In accordance with the present invention as

10   described above, in a case where printing is performed by discharging ink to a print medium from an ink-jet printhead having plural printing elements, capable of discharging ink droplets in plural different sizes, the number of concurrently-driven printing elements among

15   printing elements corresponding to the respective one of the plural sizes of ink droplets is counted based on input print data, then based on the counted result, a drive pulse to be applied to the concurrently-driven printing elements is determined, and the drive pulse is

20   applied to the concurrently-driven printing elements.

The invention is particularly advantageous since an optimum drive pulse can always be applied to printing elements corresponding to the respective one of plural sizes of ink droplet.

25   In this manner, a stable printing density can be obtained without degradation of printing elements.

Other features and advantages of the present

invention will be apparent from the following

description taken in conjunction with the accompanying

drawings, in which like reference characters designate

the same name or similar parts throughout the figures

5   thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated

10   in and constitute a part of the specification,

illustrate embodiments of the invention and, together

with the description, serve to explain the principles

of the invention.

Fig. 1A is a perspective view showing the

15   schematical structure of an ink-jet printing apparatus

as a typical embodiment of the present invention;

Fig. 1B is a schematic diagram showing an example

of nozzle arrangement in a printhead;

Fig. 2 is a block diagram showing a control

20   construction of the printing apparatus in Fig. 1A;

Fig. 3 is a block diagram showing the internal

constructions of a head logic 105a and a head logic

105b;

Fig. 4 is a timing chart showing various signals

25   used in a head logic 105 and a dot counter 108a;

Fig. 5 is a block diagram showing the internal

construction of a 16-SEG driver 204a;

11

Fig. 6 is a timing chart showing a BEn signal;

Fig. 7 is a timing chart showing a detailed waveform of a heat signal (Heat Sig) having a double pulse;

Fig. 8 is a block diagram showing the internal construction of a dot calculator 109;

Fig. 9 is a table showing coefficients selected based on values set in a register 601;

Fig. 10 is a table showing the internal structure of a heat table 111';

Fig. 11 is a flowchart showing print control processing for drive pulse generation; and

Fig. 12 is a graph showing the relation between the number of concurrently-driven printing elements and the voltage drop.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will now be described in detail in accordance with the accompanying drawings.

Note that the following embodiment exemplifies a printing apparatus which employs an inkjet printhead.

In this specification, the terms "print" and "printing" not only include the formation of significant information such as characters and graphics, but also broadly includes the formation of images,

12

figures, patterns, and the like on a print medium, or the processing of the medium, regardless of whether they are significant or insignificant and whether they are so visualized as to be visually perceivable by

5   humans.

Also, the term "print medium" not only includes a paper sheet used in common printing apparatuses, but also broadly includes materials, such as cloth, a plastic film, a metal plate, glass, ceramics, wood, and

10 leather, capable of accepting ink.

Furthermore, the term "ink" (to be also referred to as a "liquid" hereinafter) should be extensively interpreted similar to the definition of "print" described above. That is, "ink" includes a liquid

15 which, when applied onto a print medium, can form images, figures, patterns, and the like, can process the print medium, and can process ink (e.g., can solidify or insolubilize a coloring agent contained in ink applied to the print medium).

20   Fig. 1A is a perspective view showing the schematical structure of an ink-jet printing apparatus (hereinbelow, referred to as a "printing apparatus") as a typical embodiment of the present invention.

A printhead 1 used in this embodiment discharges

25 ink droplets by thermal energy, based on a method, among ink-jet printing methods, of particularly heating ink by using electrothermal transducers such as heat

generation resistors as energy generation means,
thereby realizes high resolution and high accuracy in
printed images.

　　As shown in Fig. 1A, the printhead 1 is connected
5　to an ink tank 1C containing cyan (C) ink, an ink tank
1M containing magenta (M) ink, an ink tank 1Y
containing yellow (Y) ink and an ink tank 1K containing
black (Bk) ink. The printhead 1 and the ink tanks 1C,
1M, 1Y and 1K are mounted on a carriage 2. As shown in
10　Fig. 1A, these four ink tanks are arrayed along a
lengthwise direction of a guide shaft 3, i.e., along a
moving direction of the carriage 2.

　　As shown in Fig. 1A, the printhead 1, in a
position to discharge ink downward, is mounted on the
15　carriage 2. When a bearing 2a of the carriage 2 moves
along the guide shaft 3, the printhead 1 discharges ink
droplets, to form an image for one scanning on a print
medium 4 such as a print sheet. Note that
reciprocating motion of the carriage 2 along the guide
20　shaft 3 is performed via a timing belt 7 by rotation of
a pulley 6 which receives a driving force transmitted
from a carriage motor 5.

　　When printing by one scanning by the printhead 1
has been completed, the printhead 1 stops printing. At
25　this time, a conveyance motor 9 is driven, and the
print medium 4 on a platen 8 is conveyed by a
predetermined amount in a direction vertical to the

moving direction of the carriage 2. Then, the printhead 1 performs the next image formation for one scanning while the carriage 2 moves along the guide shaft 3. These operations are repeated until an image

5   is printed on the entire print medium 4.

In Fig. 1A, on the right side of the main body of the printing apparatus, a recovery device 10 which performs recovery operation for maintaining a good ink discharge condition is provided. The recovery device

10   10 is provided with preliminary discharge orifices (not shown) for preliminary discharge for prevention of clogging on its side. The recovery device 10 includes a cap 11 for capping an ink discharge surface of the printhead 1, a wiper 12 for wiping the ink discharge

15   surface of the printhead 1, a suction pump (not shown) for sucking ink from the ink discharge nozzles (hereinbelow referred to as "nozzles") of the printhead 1, and the like.

Further, the printing apparatus of this

20   embodiment has an encoder scale 13 and an encoder 14 to detect a moving speed of the carriage 2, and performs feed-back control the carriage motor 5 upon driving of the motor. Further, as the encoder 14 reads position information of the encoder scale 13, an ink discharge

25   timing from the printhead 1 (hereinafter referred to as "heat timing") is obtained.

Note that the printhead 1 used in the embodiment

15

is a color printhead for color printing, supplied with four color inks from the above-described four ink tanks, in which one nozzle array corresponds to one color ink. The respective nozzle arrays (4 arrays) are arrayed in

5   the moving direction of the carriage 2.

Fig. 1B is a schematic diagram showing an example of the nozzle arrangement to discharge the black (Bk) ink in the printhead 1.

In Fig. 1B, the nozzle array to discharge the

10   black (Bk) ink includes a large diameter nozzle to discharge large ink droplets and a small diameter nozzle to discharge small ink droplets arranged alternately in its array direction (the conveyance direction of the print medium). The resolution between

15   the large diameter nozzles is 300 dpi, and that between the small diameter nozzles is 300 dpi. The large diameter nozzles and the small diameter nozzles are respectively provided with a heater used for discharging large ink droplets (hereinbelow, "L

20   heater") and a heater used for discharging small ink droplets (hereinbelow, "S heater").

Fig. 2 is a block diagram showing a control construction of the printing apparatus in Fig. 1A.

In the construction in Fig. 2, print data (color

25   print data) sent from a host PC 106 is received by an interface (hereinbelow "I/F") control block 107 in the printing apparatus. The received data is bitmapped to

16

print data of respective color components (YMCBk), and the bitmap data are transferred to a DRAM 101 by a DMA controller 102 and temporarily stored in the DRAM 101 under the control of a CPU 110.

5   The bitmapped print data stored in the DRAM 101 are read by the DMA 102, while an encoder signal is inputted for detection of the position of the printhead 1, and transferred to a head logic 105 of the printhead 1 via a sequence controller 104. At this time, the

10   transferred data is outputted as print signals (P_DATA 1 and P_DATA 2) in accordance with a clock signal (CLK) from the sequence controller 104. Then, after the data transfer, a latch signal (Latch Sig) is outputted to the head logic 105, and the print signals are latched

15   by a latch circuit (not shown) in the head logic 105.

On the other hand, the sequence controller 104 generates a block selection signal (Block Sig) by a block generation circuit 103, outputs the signal to the head logic 105 and also outputs a heat signal (Heat

20   Sig) to the head logic 105. In accordance with these signals, the large number of printing elements are divided into plural blocks and time-divisional block driving is performed.

Note that the head logic 105 is a head control

25   logic to drive printing elements for one array (corresponding to one color component) among four nozzle arrays in the printhead 1. Actually, four head

17

logics 105 are built in the printhead 1, however, for simplicity of explanation, only one head logic is shown. Further, one head logic 105 has an LH head logic 105a and an SH head logic 105b for respectively driving the

5   L heaters and S heaters of the respective nozzles.

Upon start of printing operation, a dot counter 108a respectively counts the number of ink discharges using the L heaters (Lcount) and the number of ink discharges using the S heaters (Scount) by each

10   transfer of print data to the print head, based on the bitmapped print data. The results of counting by the dot counter 108a are inputted into a dot calculator 109, in which the results are multiplied by predetermined coefficients. The results of multiplication are

15   inputted into a heat table 111', and heat setting values are read from the heat table 111' in correspondence with the results of multiplication. The read values are fed-back to the sequence controller 104.

On the other hand, a dot counter 108b accumulates

20   the number of ink discharges performed by the plural printing elements of the printhead, by each transfer of print data to the printhead, and the result of accumulation is used for estimation of a temperature of the printhead and detection of residual ink amount by

25   the CPU 110. As this counter accumulates the number of ink discharges, it keeps the count from several hundred thousands to several millions.

18

Fig. 3 is a block diagram showing internal

constructions of the head logic 105a and the head logic

105b. Further, Fig. 4 is a timing chart showing

various signals used in the head logic 105 and the dot

5   counter 108a.

The head logic 105a and the head logic 105b are

respectively provided with 16-SEG drivers 204a to 204h

for driving the heaters of the 16 printing elements.

These eight drivers are supplied with driving power via

10   a common power source line.

On the other hand, as shown in Fig. 4, the print

signal P_DATA 1 (in case of the head logic 105a) or the

print signal P_DATA 2 (in case of the head logic 105b),

serially inputted into an 8-bit shift register 203 in

15   synchronization with the clock signal (CLK), is latched

by an 8-bit latch circuit 202 by the latch signal

(Latch Sig). When the heat signal (Heat Sig) is

supplied to an AND circuit 205, respective bits b0 to

b7 of the latched 8-bit print signal are supplied to

20   the eight drivers. In Fig. 4, the print signal is

simply indicated as P_DATA without discrimination

between the head logic 105a and the head logic 105b as

a destination.

Further, the 4-bit block selection signal (Block

25   Sig) is decoded by a 4 to 16 decoder 201 and supplied

to the eight drivers 204a to 204h.

Note that the eight 16-SEG drivers 204a to 204h

19

have the same construction.

Further, as shown in Fig. 4, in the dot counter
108a, the count value (Counter) is incremented when a
count pulse (Count Pulse) generated based on the clock
5   signal (CLK) and the print signal (P_DATA) are at a
high level, and the count value is reset to "zero" when
the latch signal (Latch Sig) becomes the high level.
In this example, only one count output value is shown
for simplicity of explanation, however, Lcount and
10 Scount are actually outputted. Processing of the count
outputs will be described in detail later.

Fig. 5 is a block diagram showing the
construction of the 16-SEG driver 204a.

As shown in Fig. 5, the 16 printing elements are
15 respectively constructed with one power transistor, one
resistor (heater) and one AND circuit having reference
numerals 301a to 301p, 302a to 302p, and 303a to 303p.

In Fig. 5, the bit b0 of the latched 8-bit print
signal is inputted into one terminal of the 16 AND
20 circuits 303a to 303p, and the power source line is
connected to the 16 resistors (heaters) 302a to 302p.
Further, respective bits (BE0 to BE15) of the block
selection signal decoded by the 4 to 16 decoder 201 are
inputted into the other terminals of the AND circuits
25 303a to 303p. Further, the power transistors 301a to
301p are connected to the GND.

In this arrangement, if the input print signal b0

20

is ON, the power transistor corresponding to "ON"

signal among the block selection signals (BE0 to BE15)

is driven, and as a result, a corresponding heater is

heated, and ink discharge is performed.

5   Fig. 6 is a timing chart showing the BEn signal.

In Fig. 6, as power transistors corresponding to

the decoded block selection signals (BE0 to BE15) are

sequentially driven, the resistors (heaters) 302a to

302p are sequentially heated, and ink discharge is

10   performed.

Note that the heat signal (Heat Sig) has a double

pulse waveform.

Fig. 7 is a timing chart showing a detailed

waveform of the heat signal (Heat Sig) having a double

15   pulse.

In double-pulse drive of performing ink discharge

by application of double pulse, preliminary ink heating

performed by a pulse ON_Time 1 (prepulse) attains more

stable discharge. Further, ink discharge is actually

20   performed by a pulse ON_Time 2 (main pulse). In this

embodiment, the pulse width of the main pulse is varied

in accordance with the number of concurrently-driven

printing elements.

Note that as the pulse width modulation, all of

25   the prepulse and OFF_Time 1 (off-time) as well as the

main pulse may be varied.

Fig. 8 is a block diagram showing the internal

construction of the dot calculator 109.

In Fig. 8, a coefficient K1 used for multiplication of the Lcount and a coefficient K2 used for multiplication of the Scount inputted from the dot

5   counter 108a are set in a register 601. These coefficients are rewritable by the CPU 110.

The coefficients K1 and K2 are respectively inputted into the L heater (LH) dot calculator 602 and the S heater (SH) dot calculator 603. Using Lcount and

10   Scount inputted into the respective calculators, the LH dot calculator 602 calculates Lcount + K1 * Scount, and the SH dot calculator 603 calculates K2 * Lcount + Scount. The result of calculation from the LH dot calculator 602 is outputted as L heater pulse table

15   number (LHtable), and the result of calculation from the SH dot calculator 603 is outputted as S heater pulse table number (SHtable), to a heat table 111'.

Fig. 9 is a table showing the coefficients selected based on the values set in the register 601.

20   In Fig. 9, for example, if "11" for the L heater and "11" for the S heater are set as the register values, 12/8 is employed as an S heater dot calculation coefficient (K2) and 5/8 is employed as an L heater dot calculation coefficient (K1). These values are

25   determined based on the respective heater resistor values. In this embodiment, the ratio of heater resistor values (L heater:S heater) is about 12 : 5.

22

For example, if Lcount = 8 and Scount = 6 hold, 8 + 6 * 5/8 ≅ 11 holds as the result (LHtable) of calculation by the LH dot calculator 602, and 8 * 12/8 + 6 ≅ 18 holds as the result (SHtable) of calculation

5   by the SH dot calculator 603.

Note that in this embodiment, fractions below decimal point are discarded, however, they may be rounded up or rounded off.

The heat table 111' is referred to using the

10   results of calculation obtained as above.

Fig. 10 is a table showing the internal structure of the heat table 111'.

The heat table 111' is referred to using the outputs from the dot calculator 109, LHtable and

15   SHtable. For example, in the above-described example, if LHtable = 11 holds, a pulse table No. "11" shown in Fig. 10 is addressed and the corresponding L heater ON_Time 2 is read, and if SHtable = 18 holds, a pulse table No. "18" is addressed, and the corresponding S

20   heater ON_Time 2 is read. That is, the main pulse width for L heater is 2.20 μS and the main pulse width for S heater is 2.14 μs.

The read values are fed back to the sequence controller 104, and the pulses of heat signal (Heat

25   Sig) are generated based on the values and supplied to the printhead.

Next, print control processing in the printing

apparatus having the above-described construction will be described with reference to the flowchart of Fig. 11.

Fig. 11 is a flowchart showing print control processing for drive pulse generation.

First, at step S101, a print signal is inputted from the host PC 106 and temporarily stored into the DRAM 101. Next, at step S102, the sequence controller 104 reads the print signal held in the DRAM 101 via the DMA controller 102 upon heat timing based on the encoder signal generated by the encoder 14.

At step S103, the dot counter 108b counts the number of dots which cause ink discharge in one of the respective blocks of the printhead, based on the read print signal, and at step S104, the dot calculator 109 multiples the counted number of dots by the above-described coefficients. Then at step S105, in correspondence with the values (LHtable and SHtable) resulted from the multiplication, a parameter value (in this embodiment, the main pulse width is ON_Time 2) for defining the drive pulse is read from the heat table 111'.

At step S106, the sequence controller 104 generates heat pulses with the read main pulse width, and transfers the heat pulses with the L heater print signal (P-Data 1) and the S heater print signal (P-Data 2) to the head logic 105 in the printhead 1. At step S107, printing is performed for one block of printing

24

elements in the printhead 1.

At step S108, it is determined whether or not the printing operation for all the 16 blocks of the printhead has been completed. If the printing

5 operation has not been completed, the process returns to step S103, at which the number of dots for ink discharge in the next block is counted.

On the other hand, if the printing operation has been completed, the process proceeds to step S109, at

10 which it is determined whether or not printing for one scanning of the printhead has been completed. If it is determined that the printing has not been completed, the process returns to step S102, at which the printing is continued after input of the next heat timing. On

15 the other hand, if it is determined that the printing has been completed, the process ends.

As described above, according to the embodiment, even in a case where printing is performed by using a printhead having heaters for discharging large size of

20 ink droplets and heaters for discharging small size of ink droplets, optimum drive pulses are applied to the respective heaters in correspondence with the number of concurrently-driven heaters. This arrangement controls voltage drop which occurs in the respective printing

25 elements, and this results in stable printing density.

Note that in the above-described embodiment, the printhead performs printing using large and small sizes

25

of ink droplets, however, even in a case where printing
is performed using more sizes of ink droplets, similar
advantages can be attained by performing dot counting
by using the dot counters corresponding to the number
5   of sizes of ink droplets.

Further, in the printhead according to the above-
described embodiment, the large diameter nozzles for
discharging large size of ink droplets and the small
diameter nozzles for discharging small size of ink
10   droplets are alternately arranged in the nozzle array
direction, and the large diameter nozzles and the small
diameter nozzles are respectively provided with heaters
for discharging large size of ink droplets and heaters
for discharging small size of ink droplets, however,
15   the present invention is not limited to this printhead.
For example, the present invention is applicable to a
printhead where each nozzle has a heater for
discharging large ink droplets and a heater for
discharging small ink droplets such that different
20   sizes of ink droplets can be discharged from each
nozzle by drop modulation.

Note that in the above embodiment, the liquid
discharged from the printhead has been described as ink,
and the liquid contained in the ink tank has been
25   described as ink. However, the liquid is not limited
to ink. For example, the ink tank may contain
processed liquid or the like discharged to a print

medium to improve fixability or water repellency of a
printed image or to increase the image quality.

The embodiment described above comprises means
(e.g., an electrothermal transducer) for generating

5   heat energy as energy utilized upon execution of ink
discharge, and adopts the method which causes a change
in the state of ink by the heat energy, among the ink-
jet printing method. According to this printing method,
a high-density, high-precision printing operation can

10   be attained.

As the typical arrangement and principle of the
ink-jet printing system, one practiced by use of the
basic principle disclosed in, for example, U.S. Patent
Nos. 4,723,129 and 4,740,796 is preferable. The above

15   system is applicable to either one of so-called an on-
demand type and a continuous type. Particularly, in
the case of the on-demand type, the system is effective
because, by applying at least one driving signal, which
corresponds to printing information and causes a rapid

20   temperature rise exceeding nucleate boiling, to each of
electrothermal transducers arranged in correspondence
with a sheet or liquid channels holding a liquid (ink),
heat energy is generated by the electrothermal
transducer to effect film boiling on the heat acting

25   surface of the printhead, and consequently, a bubble
can be formed in the liquid (ink) in one-to-one
correspondence with the driving signal. By discharging

27

the liquid (ink) through a discharge opening by growth and shrinkage of the bubble, at least one droplet is formed. If the driving signal is applied as a pulse signal, the growth and shrinkage of the bubble can be

5   attained instantly and adequately to achieve discharge of the liquid (ink) with particularly high response characteristics.

     As the pulse driving signal, signals disclosed in U.S. Patent Nos. 4,463,359 and 4,345,262 are suitable.

10   Note that further excellent printing can be performed by using the conditions of the invention described in U.S. Patent No. 4,313,124 which relates to the temperature rise rate of the heat acting surface.

     As an arrangement of the printhead, in addition

15   to the arrangement as a combination of discharge nozzles, liquid channels, and electrothermal transducers (linear liquid channels or right angle liquid channels) as disclosed in the above specifications, the arrangement using U.S. Patent Nos.

20   4,558,333 and 4,459,600, which disclose the arrangement having a heat acting portion arranged in a flexed region is also included in the present invention.

     Furthermore, as a full line type printhead having a length corresponding to the width of a maximum print

25   medium which can be printed by the printer, either the arrangement which satisfies the full-line length by combining a plurality of printheads as disclosed in the

28

above specification or the arrangement as a single printhead obtained by forming printheads integrally can be used.

In addition, the present invention may employ not only a cartridge type printhead, in which an ink tank is integrally arranged on the printhead itself, but also an exchangeable chip type printhead which can be electrically connected to the apparatus main unit and can receive ink from the apparatus main unit upon being mounted on the apparatus main unit.

It is preferable to add recovery means for the printhead, preliminary auxiliary means, and the like provided as an arrangement of the printer of the present invention since the printing operation can be further stabilized. Examples of such means include, for the printhead, capping means, cleaning means, pressurization or suction means, and preliminary heating means using electrothermal transducers, another heating element, or a combination thereof. It is also effective for stable printing to provide a preliminary discharge mode which performs discharge independent of printing.

Furthermore, as a printing mode of the printer, not only a printing mode using only a primary color such as black or the like, but also at least one of a multi-color mode using a plurality of different colors or a full-color mode achieved by color mixing can be

29

implemented in the printer either by using an
integrated printhead or by combining a plurality of
printheads.

In addition, the ink-jet printer of the present
5   invention may be used in the form of a copying machine
combined with a reader, and the like, or a facsimile
apparatus having a transmission/reception function, in
addition to an integrally-provided or stand-alone image
output terminal of an information processing equipment
10   such as a computer.

As many apparently widely different embodiments
of the present invention can be made without departing
from the spirit and scope thereof, it is to be
understood that the invention is not limited to the
15   specific embodiments thereof except as defined in the
appended claims.